coincide with the smallest depressions in the temperature curve; this relation ceased about 1896, hence the peculiar inversion already referred to.

Other periodicities have been recognized. A 32–33-month period at Batavia may be a combination of the 2-year period already referred to and a 3.7-year period suspected by Lockyer. Secular changes of relatively long period (35 years and over 100 years) also are probable. The researches of Clayton have recognized correlations in daily temperature and pressure fluctuations at various stations over the earth and the fluctuations in the daily heat radiation of the sun as measured by Abbot and Fowle, the same three types appearing in these meteorological variations as have been noted in the long-time variations. Krogness recognizes 14-day and 27-day periods in magnetic storms, as well as in air-pressure gradients, wind, and temperature, in northern Norway.

To summarize the results of these investigations: In different groups of areas on the earth the meteorological elements (temperature, barometric pressure, rainfall, etc.) fluctuate or pulsate, so to speak, in time with one another, while in other groups of areas the fluctuations or pulsations are exactly inverted, and finally, some areas show transition stages between the two. The result of all this is a very complicated picture of the meteorological fluctuations. But by means of appropriate analyses we see that from this complicated and apparently chaotic set of fluctuations there arises a clear picture of the very intimate relation between all these variations and the variations in the sun's activity. We have seen that even changes of very short duration in the sun's radiation (of heat as well as electricity) are distinctly repeated in our meteorological conditions and in the surface temperature of the ocean. The effects of the solar variations are probably transferred by means of variations produced in the distribution of pressure in our atmosphere. Changes in solar radiation probably first affect the higher layers of our atmosphere, and thus create an unrest which in turn is transmitted to the lower strata near the earth's surface.

Such dynamic changes will produce different effects in different regions of the earth. But by thorough and complete analyses of the great meteorological material now at hand it may be possible to find the general rules. This will be an important step forward toward understanding the laws ruling our atmosphere.

For this purpose it will also be of the greatest importance to have the wonderful researches of Abbot and Fowle continued with the greatest possible efficiency. These investigations of the sun's radiation of heat, which they have been carrying on for a long series of years at Washington, Mount Wilson, Mount Whitney, and in Algeria, have given us the remarkable revelation that our sun is a variable star, the most important discovery that has been made in this field in many years.

WHIRLWIND OF JANUARY 26, 1918, AT PASADENA, CAL.

By Ford Ashman Carpenter, Meteorologist.

[Dated: Weather Bureau, Los Angeles, Cal., Apr. 18, 1918.]

On the afternoon of January 26, 1918, a whirlwind of considerable severity, showing many of the characteristics of a tornado, visited the city of Pasadena, Cal. Although the storm attained considerable violence and damaged property to the extent of about $10,000, no lives were lost and no one was injured. The material loss was widely distributed among one hundred or more persons.

The storm was interesting from a meteorological viewpoint as it was the first of its kind reported from southern California.

The topographic features of Pasadena.—The topographical features of Pasadena should be taken into consideration in studying this storm.[1] The city is located 25 miles from the Pacific Ocean at the southern base of the Sierra Madre. These mountains rise abruptly to an average elevation of 5,000 feet above sealevel; an idea of the wall-like character of the northern background to the city may be gained from the fact that within four miles of Pasadena one of the crests of the range reaches an elevation of 5,000 feet above the city.

General and local weather conditions preceding the storm.—The morning weather map of January 26, 1918, showed a belt of high atmospheric pressure over the northern part of the country and a double-centered low
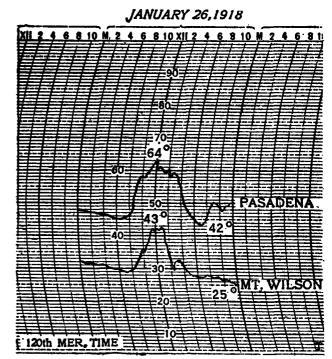
JANUARY 26, 1918

Fig. 1.—Thermograms from Pasadena, Cal., and Mount Wilson for Jan. 26, 1918, when hail and a whirlwind visited Pasadena in the afternoon.

area in Arizona, New Mexico, and Oklahoma. It was in the southwestern quadrant of this depression that the Pasadena storm occurred.

The first indication of unusual weather was the appearance of a solitary cloud which formed with great suddenness in that vicinity. The writer observed this huge convectional cloud from the Los Angeles station about 1:30 p. m. January 26, 1918, and it rapidly assumed the proportions and character of the cumulo-nimbus type. Within an hour this structure underwent rapid changes, but in three hours the sky was clear again. This cloud was observed from Mount Wilson (4 miles distant horizontally and 1 mile vertically) the upper edges appearing as a misting fog, boiling up 3,000 feet or more above that mountain. The temperature differences between the base and the top of the mountain amounted to about 20° F., as the thermograph traces from Pasadena and Mount Wilson show (fig. 1).

Course of the storm.—In many respects this whirlwind failed to follow the usual easterly course characteristic of

---
[1] For a topographic map of Los Angeles, Pasadena, and vicinity see this Review, June, 1914, 42: 387.—c. a. jr.
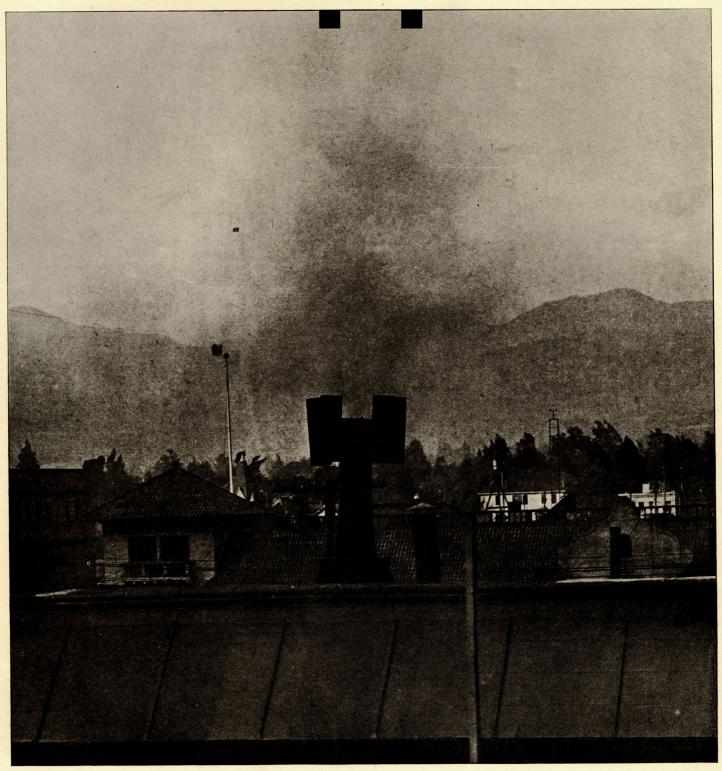
FIG. 2.—Whirlwind of Jan. 26, 1918, at Pasadena, Cal., viewed from a point on Colorado Street between Fair Oaks and Marengo Streets, looking northward.) Photo. by
E. P. Groetzinger.)

Note effect of wind on tree tops which point inward from either side showing decided anticlockwise motion of the wind. The funnel-shaped cloud was about 3,500 feet from
the camera.   Cooperative station seen in the middle distance, 1 block from the camera.   Just over the flagpole on the left are seen two roofs (quadrilaterals) flying through the
air.—R. P. Hamlin, Cooperative Observer.

tornados.[2] The path of this disturbance being one-quarter of a mile southeastward, one-half mile eastward, three-quarters of a mile northwestward, one-quarter westward and one quarter northwestward. The storm traveled in all about 2 miles of city blocks [along a path recurving anticlockwise as described] the average direction was northwesterly. Figure 2 [not reproduced] shows the path of the storm and also the locations of the cooperative Weather Bureau station of Pasadena. After the whirlwind left the city limits it continued in a northwesterly direction and ascended the mountain ridge between Mount Lowe and Mount Markham. The writer noticed the effects of this storm when traversing the trail in that vicinity some weeks afterwards. One of the cooperative observers in these mountains reports that he heard the approach of the storm and the crashing of the pine trees as it plowed its way through the timber. Shortly after reaching the higher elevations the storm died out; the writer did not observe any damaging effects beyond the mountain ridge in which Mount Lowe and Mount Markham are located.

Description of the storm by eye-witnesses.—Fair weather prevails in southern California during more than three-quarters of the year, therefore any occurrence out of the ordinary is given unusually intelligent attention by the people generally. The case of the Pasadena storm was no exception to the rule. From a quantity of data collected the following two accounts are submitted. Prof. Ferdinand Ellerman of the staff of the Mount Wilson Solar Observatory writes Dr. W. J. Humphreys of the central office of the Weather Bureau as follows:

On January 26 [1918], we had a freak storm in Pasadena, where hail fell several inches deep in a very limited area, just as if it had been dumped, and a small-sized cyclone [!] did considerable damage. About 200 yards from my residence a pine tree over 2 feet through was uprooted, and many buildings unroofed, and barns and garages picked up and demolished. As near as I can learn the direction of rotation was clockwise, which, though contrary to cyclones in general, is not surprising to me, as considering the form of development it might take either direction. The sky on Mount Wilson was practically clear, and fog condensing from the slight rain the night before, increased in volume and banking up quite 3,000 feet above Mount Wilson's level, in a cumulus form. There was very little wind in Pasadena and a fair north wind on Mount Wilson. This occurred about 2 to 2:30. From the mountain we could not see the cyclone [i. e. tornadic storm] as the fog cut off the view.

From the notes of the cooperative observer at Pasadena, Mr. R. P. Hamlin, deputy city engineer, it has been possible to trace the path of the storm across the city.

Mr. Edwin R. Sorver, former cooperative observer at Pasadena writes:

The day was somewhat cloudy. About 2 p. m. it became very dark and a small tornado developed in the neighborhood of Fair Oaks Avenue and Union Street, traveling in a southeast direction for 2 blocks to Colorado Street and the Santa Fe tracks, tearing off roofing paper and blowing in a show window. It then followed Colorado Street east for 4 blocks, now and then becoming quite strong. A small amount of rain fell and hail fell. At Colorado Street and Euclid Avenue it blew in another show window and then turned directly at right angles going north and then northwest, which direction it kept until it dispersed. It now [after turning northwestward] began to grow very much in strength, uprooting large trees, taking the entire roof off an old school and striking the side of the Christian Church at Marengo and Walnut Streets. This church was built of large squares of concrete blocks. It demolished the entire side, throwing down several solid blocks together which probably weighed several tons. Its path, which was about 200 feet wide, could now be easily traced as it uprooted every tree, among them some very large peppers, and took off a number of roofs. Considerable damage was also caused by trees and débris, which were carried high up and then dropped (in one instance) through a house which was to one side of its path. The worst damage was done around the corner of Orange Grove Avenue and

Lincoln Streets, soon after which it dispersed. Here an entire orange grove of old trees was uprooted. This was on the place where the first house in Pasadena was built, which was still standing and was unhurt. It partly demolished a bungalow school, took the top off a church, completely wrecked a large garage, took the side out of a two-story house, and did considerable damage to other houses. The most remarkable part was that no one was hurt. The very black clouds did not follow the tornado, but moved off in the opposite direction. Snow and hail fell some 2 to 3 miles distant. There were, however, some white, low clouds which seemed to follow right over the tornado and which it connected with the ground many times. After it left Euclid Avenue and Colorado Street going northwest it appeared as a large and high whirling column of dust. Gradually, however, as it grew in strength it became a black funnel-shaped column resembling a waterspout. Once or twice it seemed to almost disappear, but then in not over five seconds would resume its old form. It did not seem to travel so very fast. At times there would be sucked through the center of it a fairly large column of what looked to be steam; this no doubt being intense condensation. The white clouds would then dip down into the column. It seemed to disperse very quickly as it moved into a section that was more open.

The above notes were made from Mr. Sorver's location in the Mather Building [No. 3, on fig. No. 2, not reproduced].

Deputy City Engineer R. P. Hamlin furnishes the photograph, figure 2, which shows the whirlwind just before it reached its maximum intensity. This illustration shows the counterclockwise wind movement as pictured by the inclination of the tree tops. Incidentally the location of the wind apparatus of the cooperative Weather Bureau station is given. Although the storm skirted this apparatus it is noted that the anemometer wind record sheet [not reproduced] shows no unusual velocities. The maximum wind, 18 miles per hour (the usual diurnal extreme), was reached at 2 p. m.

Several interesting incidents of the storm are related. A member of the Forest Service reports his aneroid barometer broken from the effects of the passage of the storm, the diaphragm being permanently collapsed. Another witness reports all four of the tires of his automobile, standing in the street, as having been deflated. It is also reported that just before the cottage [fig. 4 not reproduced] was destroyed the occupant started to close the kitchen door which had been blown open by the wind; before the door was reached the house was unroofed and the sides blown outward. All of these occurrences point strongly to tornadic action.

EVAPORATION FROM A CIRCULAR WATER SURFACE.[1]

By N. THOMAS and A. FERGUSON.

The rate of evaporation from a circular water surface into a quiescent atmosphere was shown by Stefan to depend theoretically upon the radius of the surface, not upon its area. Experiments were made by the authors, both indoors and in the open air to test the dependence of evaporation upon the dimensions of the surface of evaporation, and upon the depths of the surface below the rims of the crystallizing dishes containing the water which varied in radius from 2 to 10 centimeters. If E is the rate of evaporation and a the radius of a dish, then assuming that $E = Ka^n$ where K depends on external conditions, it is found that in practice n is never so small as unity, the value required by Stefan's result, but varies from 1.5 when the dish is brimful, to about 2.0 when the depth of the surface is 3 centimeters or more below the brim of the dish. With the latter value, evaporation is proportional to the area of the evaporat-

*o. g., Henry, A. J. Cyclones, tornadoes, thunderstorms, squalls. MONTHLY WEATHER REVIEW, January, 1918, 46: 23–25.

1 Phil. Mag., London, etc., October, 1917, 34: 308–321.